COGNITIVE DEPLETION IN EMOTION REGULATION: AGE DIFFERENCES DEPEND ON REGULATION STRATEGY

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Cognitive Depletion in Emotion Regulation:
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SUMMARY

Recent work has suggested that emotion regulation of inner emotional experience requires fewer cognitive resources for older adults than for young adults (Scheibe & Blanchard-Fields, 2009). The present study investigated whether cognitive costs are reduced for various types of emotion regulation strategies or only for certain types. The suppression of emotional expression, for example, is a particularly costly strategy for young adults, but little information exists regarding its cognitive costs for older adults. Furthermore suppression of emotional expression is not a strategy that older adults are likely to use or that they become more effective at using. By contrast, the regulation of inner emotional experience has been shown to be more effective in older adults and presents less of a cognitive cost. The present study examined the cognitive costs of regulation of inner emotional experience (to conceptually replicate previous findings) and the cognitive costs of suppression of the outer expression of emotion. The results suggest that regulating and suppressing emotions do not require the same degree of resources for older and younger adults. Whereas older adults may require more resources to suppress expression of emotions than to regulate emotions, young adults appear to require more resources to regulate emotions than to suppress the expression of emotions.

INTRODUCTION

A substantial body of research in cognitive aging supports, to a great extent, a negative developmental trajectory for cognitive functioning as people progress through older adulthood (Schaie, 1994). At the same time, there is also an accumulating literature that suggests a positive developmental trajectory exists for emotional experience and emotion regulation. Not only do older adults report use of more effective regulation strategies during interactions with others (Blanchard-Fields, 2007) and greater self-perception of emotional control (Gross, Carstensen, Pasupathi, Tsai, Skorpen & Hsu, 1997), they also more successfully down-regulate negative emotions in response to experimenter instruction (Phillips, Henry, Hosie, & Milne, 2008; Scheibe & Blanchard-Fields, 2009). There have been a number of explanations for this positive developmental trajectory. First, older adults may be more motivated than young adults to maintain positive emotions (Carstensen, Isaacowitz, & Charles, 1999), and this goal may lead them to spontaneously pursue emotion-regulatory goals even without experimenter instruction. Importantly, older adults may also choose different strategies than young adults when dealing with emotional situations and they may enact these strategies more effectively (Blanchard-Fields, Mienaltowski, & Seay, 2007; John & Gross, 2004; Phillips et al, 2008).

Age-related improvements in use of emotion regulation strategies have led researchers to explore various criteria of emotion regulation effectiveness that may suggest it improves with age. Recently, researchers have begun to explore an efficiency

hypothesis that emotion regulation may also have fewer cognitive costs for older adults (Scheibe & Blanchard-Fields, 2009). However, this research has explored only general instructions to regulate emotions, and little is known about cognitive costs of specific kinds of emotion regulation strategies. I will review the literature on cognitive costs of emotion regulation in young and older adults, and then I will outline the current study, which compares the cognitive costs of different types of emotion regulation strategies across the latter half of the lifespan. The goals of the study were: 1) to conceptually replicate the finding that older adults display reduced cognitive costs associated with emotion regulation, 2) to determine whether reduced cognitive costs for older adults are characteristic of all kinds of emotion regulation or only certain emotion regulation strategies.

Types of Emotion Regulation

Emotion regulation can occur at various points before, during, and after an emotion-eliciting event (for a review, see Gross & Thompson, 2007). People facing a potentially emotional event can choose to alter their emotional experience by avoiding the event altogether, modifying their attention to the event as the event occurs, modifying their cognitive appraisal of the event, or modifying their emotional response after it is elicited. The first three forms of emotion regulation are antecedent-focused strategies. They occur before the emotional response has been fully elicited. The fourth strategy is response-focused emotion regulation because it is focused on modifying the emotional response once it is already underway.

Much research with young adults has concentrated on two specific forms of emotion regulation: regulation of emotional experience (especially cognitive reappraisal) and suppression of emotional expression. Cognitive reappraisal is an antecedent-focused strategy during which people change the way that they view an event so that it carries different emotional meaning. For example, a person may attend a friend's funeral (which is generally perceived in terms of negative emotions like sadness and feelings of loss) and think about all of the wonderful things that happened in the course of the friend's life. Another way of dealing with negative emotions is suppression. Suppression is a response-focused emotion regulation strategy during which a person may try to hide their outward or inward expression of emotions. For example, at a funeral, a person may adopt a stoic expression, keeping her entire face and body still and expressionless.

Antecedent-focused strategies like reappraisal and response-focused strategies like suppression do not only occur at different points in the emotion process, they also are differentially effective. Suppression of expression, for example, only results in decreased outward appearance of negative emotion but not in decreased inner experience of negative emotion (Richards & Gross, 2000). In fact, it may even increase autonomic nervous system activity (Gross, 1998). Reappraisal, on the other hand, is a more effective regulation strategy. It results in both decreased expression and decreased inner experience of negative emotion (Richards et al, 2000). Because antecedent strategies are enacted early in the process of generating an emotion, they may prevent an emotion from developing fully (John & Gross, 2004). Suppression, on the other hand, occurs after an emotion is fully present and focuses on expression rather than inner experience, which may make it less effective.

Interestingly, older adults may be more likely to use effective strategies, like reappraisal, than less effective strategies like suppression of expression (John & Gross, 2004). Consistent with the findings of John and Gross, a correlational study (Gross, Carstensen, Pasupathi, Hsu, Tsai, & Skorpen, 1997) found that older adults reported greater control of their inner experience of emotion, though they reported less improvement in their ability to control external expression of emotion. In fact, older adults also may be more effective at using strategies to down-regulate inner experience of negative emotions than young adults, though they are equally effective at using expressive suppression (Phillips et al, 2008).

Not only are different emotion regulation strategies differentially effective, they also may require different amounts of cognitive resources to enact. As with any practiced skill, effectiveness of different emotion regulation strategies may change with age because cognitive resources required for practiced strategies are reduced. The following section will discuss the current literature on the cognitive costs of emotion regulation for young and older adults.

Cognitive Costs of Emotion Regulation

The limited research available on the cognitive costs associated with emotion regulation suggests that different types of emotion regulation require different amounts of cognitive resources to enact, at least for young adults. In one of the few studies to investigate the cognitive costs of both regulation of expression and regulation of experience (Richards & Gross, 2000), researchers found that, for young adults, suppressing emotional expression during presentation of unpleasant pictures led to poorer

memory of the pictures. Young adults who reappraised the pictures, on the other hand, showed memory performance equal to participants who were given no regulation instructions. Ostensibly, participants who were asked to suppress their expression of emotions had to use some of their attentional resources to monitor their expressiveness, which left fewer resources available for attending to the stimuli. No comparable studies exist that compare regulation of experience and expressive suppression in older adults. If suppression of expression is more costly than regulation of inner experience for older adults, this could explain why they tend to use regulation of inner experience strategies, like cognitive reappraisal, instead of suppression of expression. Further, as a whole, older adults have been purported to have fewer cognitive resources than young adults, which could mean that using costly emotion regulation strategies like suppression of expression would have an even greater impact on cognitive performance for this age group than it has for young adults.

Research with Young Adults on Cognitive Costs of Emotion Regulation

Studies with young adults suggest that emotion regulation (specifically, expressive suppression) is associated with cognitive costs. Baumeister and colleagues propose that people have limited self-control resources that are temporarily depleted whenever they are used (Gailliot, Schmeichel & Baumeister, in press; Schmeichel, Vohs & Baumeister, 2003). Baumeister and his colleagues define self-control as enabling "a person to restrain or override one response, thereby making a different response possible" (Baumeister, Vohs, & Tice, 2007, pp. 351). These resources seem to be involved in executive functioning (Schmeichel, et al, 2003; Shamosh & Gray, 2007). After performing a task that requires self-control, people temporarily have fewer resources with

which to perform subsequent self-control tasks, causing their performance on those tasks to suffer (Schmeichel et al, 2003).

For young adults, regulating emotions seems to require self-control resources (Dillon, Ritchey, Johnson, & LaBar, 2007; Galliot et al., 2006; Schmeichel et al, 2003; Shamosh et al, 2007). Suppressing expression of negative emotions induced by a sad video clip (Shamosh & Gray, 2007), a video clip depicting destruction of the environment (Schmeichel, Vohs, & Baumeister, 2003), thoughts about death (Galliot et al, 2006), or a standardized set of negative pictures (IAPS; Dillon et al, 2007) decreases performance on subsequent cognitive tasks including analytical reasoning problems (Galliot et al, 2006), explicit memory tasks (Dillon et al, 2007), and the color-word stroop task (Galliot et al, 2006).

Much of the literature using Baumeister's depletion paradigm focuses on the cognitive costs of suppressing expression. Within this paradigm, there is little research that specifically addresses regulation of inner experience and the degree to which it drains cognitive resources. However, the literature does suggest that using self-control resources to regulate emotional expression hinders performance on later cognitive tasks that also require self-control. Therefore, we expected to find this same relationship in the current study, which shall be discussed later.

Research with Older Adults on Cognitive Costs of Emotion Regulation

The majority of emotion regulation research with older adults has concentrated mostly on the increased effectiveness with which older adults regulate their emotions and on the types of strategies that they are more likely to use, as discussed earlier in the

introduction. Thus far, only one study has examined cognitive costs of emotion regulation in older adults, and it used instructions to regulate inner experience of emotion rather than expressive suppression instructions, because this kind of regulation is more common in older adults (Scheibe & Blanchard-Fields, 2009).

As discussed previously, emotion regulation seems to have cognitive costs for young adults. Research suggests that older adults have lower cognitive resources and are more highly motivated to regulate their emotions. This might suggest that they allocate a greater proportion of their cognitive resources to regulating emotions at the expense of other cognitive tasks. On the other hand, emotion regulation could become less costly for older adults because they may consciously choose less costly strategies or because they have extensive practice with the process of emotion regulation, rendering it more automatic. Recent evidence in a dual-task paradigm supports the latter explanation (Scheibe et al, 2009), suggesting that emotion regulation may require fewer resources in old age. In this study, young adults who were asked to regulate their inner experience of emotion (specifically disgust) declined on performance of a concurrent cognitive task. Older adults, however, showed no decreases in performance.

In the study (Scheibe & Blanchard-Fields, 2009), older and young adults viewed a disgusting film clip, and then were asked to down-regulate their emotional reactions, maintain their reactions, or were given no instructions. The emotion of disgust was chosen because it can be elicited in older and young adults at similar levels and is easy to induce. At the same time participants followed regulation instructions, they were asked to perform a resource demanding 2-back working memory task. The 2-back task presents participants with a sequence of numbers presented individually, and participants are

supposed to indicate whether the number currently appearing onscreen does or does not match the number that appeared two screens prior. While regulating their emotions, older adults' performance continued to improve on the N-back task, while the performance of young adults decreased. Seemingly, emotion regulation required more resources for young adults, decreasing their performance on a concurrent task. Importantly, in this paradigm, there did not seem to be a cost for regulating internal experience of emotion for older adults, though there was for young. Older adults who were given regulation instructions performed as well as older adults who were given no instructions or who watched a neutral film clip prior to performing the task. This study was the first to demonstrate that regulating emotions may not be cognitively costly for older adults, and that costs of emotion regulation may decrease in old age. To further substantiate these conclusions, there are a number of questions that need to be pursued further.

Part of the difficulty in comparing cognitive costs of emotion regulation in young and older adults stems from the fact that the majority of the research with young adults investigates costs of suppression of expression in a depletion paradigm, whereas the one study that includes older adults uses a dual-task paradigm and general regulation of emotional experience instructions. From the young adult literature, we know that suppression is costly to both ongoing tasks and subsequently performed tasks. From the older adult literature, we know that experience-focused emotion regulation (like reappraisal) is more common as people age, and that in at least one study, older adults required fewer resources to regulate inner experience compared to young adults (Scheibe & Blanchard-Fields, 2009). The current study used suppression of expression and

regulation of inner experience strategies in the same paradigm (depletion), so that the cognitive costs of both kinds of regulation strategies can be compared across age groups.

The Current Study

This study further tested whether effort that is necessary to regulate emotions decreases with age. The Scheibe and Blanchard-Fields (2009) study used a dual-task paradigm. A next step was to use a different paradigm to try and conceptually replicate these findings. The cognitive depletion paradigm, used extensively with young adults, complements the dual-task paradigm for several reasons. First, the depletion paradigm provides a converging yet different way to investigate how much cognitive effort (in the depletion paradigm, self-control) is used by emotion regulation. Also, whereas a dual-task paradigm allows researchers to understand the costs of emotion regulation as it is occurring, the depletion paradigm allows researchers to estimate the cost to subsequent behavior, i.e., later cognitive tasks.

Further, the study extends the research with older adults to better understand the extent to which cognitive costs of emotion regulation are reduced in general or if they are specific to regulation of emotional experience. Evidence suggests that older adults do not become more effective at suppressing expression and they show a decrease in the use of expressive suppression (Phillips et al, 2008; John & Gross, 2004). This could be because expressive suppression is not effective and remains costly, perhaps even more so for older adults, in light of decreasing resources.

In addition to switching from a dual-task to the depletion paradigm and including suppression of expression instructions, the study also employs a different cognitive task

than the one used by Scheibe and Blanchard-Fields (2009). Not only does using a different cognitive task help reinforce the generalization of prior findings, it also helps address some potential problems with the N-back task. The N-back task was difficult for older adults, prompting concern that older adults may be experiencing floor effects. If that was the case, then the finding that performance was not significantly different for any of the regulation conditions for older adults might simply be a product of a restricted range of scores. For the current study, we wanted to identify a task that would not have ceiling effects for young adults or floor effects for older adults and that would also be cognitively demanding enough that decreases in cognitive resources would negatively affect performance. In selecting a task, it was also necessary to choose a task believed to conform to Baumeister's definition of self-control. Baumeister and colleagues describe self-control in terms of ability to override one response in favor of another (Baumeister et al, 2007). For these reasons, the color-word Stroop task was selected for this study. The Stroop task has been used by Baumeister and colleagues successfully in previous studies to show cognitive depletion in young adults (Galliot, Schmeichel, & Baumeister, 2006). Further, our piloting suggested that older adults perform nearly as well as young adults on the Stroop task, suggesting that they were not experiencing floor effects.

The study examines the cognitive costs of emotion regulation using a depletion paradigm. Participants were given practice with the microphone used for the Stroop task, regulation instructions to follow while they watch a disgusting video, and then they completed blocks of the Stroop task. The study includes three of the regulation conditions used by Scheibe and Blanchard-Fields: neutral condition (given no instructions, watch a neutral video), regulate inner experience condition, maintain

condition, and one new condition: the suppress expression condition. Reaction time and accuracy on the Stroop task are the dependent variables.

The study has two major hypotheses. Hypothesis 1: We expected to conceptually replicate the findings of Scheibe and Blanchard-Fields. Regulating inner experience of disgust should decrease performance on the Stroop task for young adults but not for older adults. Hypothesis 2: We expected that both older and young adults will show decreased performance in the suppression condition relative to the control conditions. This is based on evidence reviewed earlier that suggests that suppression of expression is costly for young adults (Richards et al, 2000; Baumeister et al, 2007). For older adults, if suppression requires considerable resources and is not well-practiced, then it should be more costly for them as well. Finally, we included measures of executive functioning and emotion regulation strategy use to evaluate whether cognitive functioning and strategy use can account for variance in the magnitude of the depletion effect.

METHOD

Overview

The study used a depletion paradigm with both older and young adults. Participants were randomly assigned to watch a disgusting film clip followed by regulation, suppression, or maintenance instructions or they watched watch a neutral film clip with no instructions. Next, they were asked to complete two blocks of Stroop trials to examine how Stroop performance is impacted by different types of regulation. Finally, participants completed a battery of cognitive tasks and other questionnaires.

Participants

The study used 145 older adults (aged 60-75) and 156 young adults (aged 20-30). The data for 25 older adults and 30 young adults was not used in the study. Participants' data was removed for computer malfunctions (OA: 3, YA: 2), failure to follow condition instructions (OA: 4, YA: 2), difficulty understanding Stroop instructions (OA:1, YA: 1), and failure to find film clip disgusting (OA: 17, YA: 25). For further description of participants, see Table 2.1 (cognitive performance) and Table 2.2 (demographic information). Older adults were recruited from the community using advertisements and were compensated $10 per hour for their participation. Young adults were recruited from the psychology participant pool and were given class credit for participation.

Table 2.1 *Comparison of young and older adults on individual difference measures.*

		Young			Older			Main Effect of Age
		M	SD		M	SD		F
ERQ								
	Reappraisal	5.1296	0.879		5.2667	1.178		1.099
	Suppression	3.2232	1.244		3.5940	1.233		5.564*
ECQ								
	Rehearsal	1.4669	0.217		1.3870	0.231		7.634*
	Aggression Control	1.6538	0.232		1.7416	0.196		10.308**
	Benign Control	1.4509	0.221		1.2720	0.184		46.904***
	Emotional Inhibition	1.3847	0.261		1.3578	0.264		0.621
Cognitive Battery								
	Forward Digit Span	11.5476	2.092		10.0833	1.973		31.624***
	Backward Digit Span	8.0714	2.453		6.4917	2.275		26.817***
	FAS fluency	42.8651	10.92		40.6667	11.943		2.255
	WCST categories	7.9600	2.119		4.6917	2.953		108.81***
	Mental Arithmetic	16.0952	2.949		13.7583	3.658		30.369***
	Cognitive Composite	0.3249	0.521		-0.3149	0.594		79.696***

Table 2.2 *Demographic information on included sample.*

	Older Adults	Young Adults
Average Age	67.7 years	20.5 years
Average Education (years)	15.5 years	14 years
Gender (female/male)	70/56	68/52

Materials

Color-word Stroop Task. The Stroop task requires participants to name the color that text is written in while ignoring the content of the text itself (Stroop, 1935). It is comprised of three kinds of trials: congruent, in which the content of the text and the color of the text are the same (e.g. the word "red" written in the color red); neutral, in which the text used is not a color word (in our version, the text is a string of X's); and incongruent, in which the content of the text and the color of the text are not the same (e.g. the word "blue" written in the color green). The Stroop trials were presented on a computer screen in red, blue, and green. Participants used a microphone for voice-keyed responding to record reaction time, and an experimenter recorded accuracy and microphone errors by hand.

There were three blocks of Stroop trials. The first block, which participants completed prior to the mood induction, was comprised of 40 neutral trials designed to acclimate participants to using the microphone for responding. Following the film clip, participants completed two more blocks of the Stroop task that included 180 trials each; 60 incongruent, 60 congruent, and 60 neutral. The trial types were randomly intermixed. Immediately after the film clip, but prior to completing the mixed Stroop blocks,

participants were given brief instructions. Participants were told they would complete another block of trials but that the new block would include trials where the text color and content did not match. The experimenter showed them one incongruent trial and told them what the correct answer was. Then, another incongruent trial was presented and participants were asked how they should answer. If participants answered correctly, they moved on to the actual task. When participants did not answer correctly, the experimenter told them the correct answer and reiterated the instructions. This entire instruction procedure took approximately 30 seconds.

Film clips. The disgusting film clip depicts a woman eating horse rectum in a competition and describing her experience. The clip lasts 2 minutes 10 seconds. The neutral film clip depicts two men having a brief discussion about a woman's dress and drinking a beer. The neutral clip lasts 2 minutes 11 seconds. Both clips have been shown previously to elicit the target emotions at comparable levels for both age groups (Shiota & Levenson, 2008). In addition, these two clips were used by Scheibe and Blanchard-Fields (2009) in their study that investigated age-related changes in cognitive costs associated with emotion regulation. Scheibe and Blanchard-Fields also found that the disgust clip elicited primarily disgust and that there were no significant differences in magnitude of disgust for older and young adults.

Cognitive Battery. The cognitive battery used for this study is from Glisky, Polster, and Rothieaux (1995) and includes the Wisconsin Card Sorting Test (WCST), the FAS fluency task (FAS; Spreen & Benton, 1977), the mental arithmetic section from the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1981), and the backward and control digit span tasks from the Wechsler Memory Scale-III (Wechsler, 1997). All of

these measures have been shown to be related to frontal lobe functioning (see Glisky et al, 1995), and the battery of tests has been used to categorize both older and younger adults into high and low frontal functioning groups.

Using scores on each of these measures, a composite frontal lobe functioning score was calculated. The scores for each measure were converted to *z* scores and then *z* scores for the four measures were averaged for each individual. This method of calculating an overall functioning score has been used previously and validated (Butler, McDaniel, Dornburg, Price, & Roediger, 2004; Glisky et al, 1995).

Emotion Control Questionnaire. In the study, two questionnaires assessing how people deal with and control emotional expression and experience were included to explore whether people's dispositional ways of dealing with emotions are related to how costly emotion regulation is for them. The Emotion Control Questionnaire (ECQ; Roger & Najarian, 1989) includes 40 items that participants answer as true or false. These items are statements about how the participant deals with emotions and emotional situations. Each participant receives a score on four aspects of emotional control: rehearsal, emotional inhibition, benign control, and aggression control. These factors were identified by the original scale creators using factor analysis. Each factor has high test-retest and internal reliability. Internal consistency, calculated using the Kuder-Richardson formula, was .86 for rehearsal, .77 for emotional inhibition, .81 for aggression control, and .79 for benign control. The test-retest reliabilities at 4 weeks were .83 for rehearsal, .89 for emotional inhibition, .80 for aggression control, and .91 for benign control (Roger & Nesshoever, 1986).

The rehearsal score is based on questions that investigate the extent to which a person dwells on negative emotions. For example, someone high on rehearsal would likely answer "true" to the question "I never forget people making me angry or upset, even about small things". The emotional inhibition component is tied to whether a person hides their emotions. For example, the highest loading on this factor is the statement: "I seldom show how I feel about things." The aggression control factor relates to how well people control violent emotional reactions in response to emotional situations: "If someone were to hit me, I would hit back." And the benign control factor involves how impulsive people are about expressing their emotions: "I often say things without thinking whether I might upset others."

Emotion Regulation Questionnaire. Participants also completed the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). In this questionnaire, participants rate how strongly they agree or disagree (on a 7 point scale) with 10 different statements about how they control their emotions. These statements each reflect use of reappraisal or suppression strategies. Each participant receives one score for endorsement of reappraisal items and another score for endorsement of suppression items. Using this questionnaire will allow us to explore how people's tendency to suppress expression or reappraise (one form of regulation of experience) covaries with how cognitively costly each of these strategies is for them. Test-retest reliability for both scales was .69 in previous testing (Gross & John, 2003).

Positive and Negative Affect Scale. The Positive and Negative Affect Scale (PANAS) is a mood measure composed of 20 emotion adjectives (Watson & Clark, 1988). For each adjective, participants are asked to rate to what extent they feel each

emotion at that moment using a 5-point scale. The emotion adjectives are either negative or positive and are used to calculate separate scores for negative emotion and positive emotion. This scale was used in this study to evaluate people's moods throughout the experiment.

Follow-up Questionnaire. The follow-up questionnaire asked participants important questions about their experience during the study in order to check manipulations and to determine whether they had prior experiences that might affect their performance on the tasks included in the study. Manipulation checks included questions about how disgusting participants found the film clip, what instructions they were given to follow during the film clip, and what specific strategies they used during the film clip. Other manipulations checks besides the follow-up questionnaire were included and are discussed in the analysis and results section.

Questions to determine whether participants had prior experience that might affect performance in the experiment include: whether they had seen the video clip before, whether they routinely watch reality television (specifically *Fear Factor* from which the clip was drawn), and whether they have done the Stroop task before and how recently.

Procedure

Participants were welcomed to the lab and seated in an individual testing room. Each participant was told that experimenters were interested in how different kinds of people perform on different kinds of tasks, including emotion-related tasks and other tasks like puzzle tasks. Informed consent was obtained.

Next, participants were informed that they would be video-taped during a portion of the experiment. Before starting, the experimenter adjusted the camera to make sure the participant was in the frame. Next, participants completed the first PANAS.

Participants were then given the practice Stroop task, which includes 40 neutral trials using the microphone. Participants then completed a second PANAS. Participants were then told that they would be switching to a different kind of task and were given regulation instructions to follow while watching the film clip. Those in the neutral control condition were asked to just watch the (neutral) film clip. Participants in the regulate condition were instructed, "Next you will be asked to watch a short film clip. The film clip has some negative content. *While you watch this film clip, we would like for you to change any negative reaction that you have. Use any strategy you have available to turn your negative feelings into positive ones.*" Participants in the maintenance condition were instructed, "*While you watch this film clip, we would like for you to maintain the intensity of your negative reaction to the film. Just keep your negative feelings going and do not try to change them in any way*." These instructions were adapted from Scheibe and Blanchard-Fields (2009). In the suppress condition, participants were instructed, "*While you watch this film clip, we would like for you to try to behave in such a way that someone watching you would not know you are feeling anything at all. Try not to show any emotion in your face or body*." These instructions were adapted from Richards and Gross (2000). Following the regulation instructions, the experimenter left the room while the participant watches the film clip. Participants' facial expressions were recorded using a webcam so that their facial expressions could later be coded to determine whether they complied with experimenter instruction.

Following the film, participants completed a third PANAS. They then completed the two mixed blocks of the Stroop task, with a break in between the blocks during which they filled out a fourth PANAS. After completing the Stroop trials, they filled out a fifth PANAS.

Next, participants were asked to repeat the regulation instructions they were given before the film clip. Then they reported what specific strategies they used while trying to enact those instructions during the film clip. These questions were used to determine whether participants complied with the instructions they were given prior to the film clip. Participants who failed to understand or comply with instructions were not included in analysis.

Before beginning the cognitive battery, participants watched a short comedy clip depicting a comedian discussing his relationship with his parents, which has been shown to elicit the same positive subjective and behavioral responses from young and older adults (Tsai, Levenson, & Carstensen, 2000). Research by Tice, Baumeister, Shmueli, & Muraven (2007) suggests that showing depleted people humorous videos or surprising them with an unexpected gift refreshes their self-control resources, leading to performance equivalent to non-depleted participants on subsequent self-control tasks. Because we gave participants a battery of cognitive tasks that should all require self-control, we deemed it important that they all be equally non-depleted when doing these tasks.

Participants then completed the WCST, forward and backward digit span, FAS, and mental arithmetic. They were encouraged to take breaks between tasks, as desired,

but few participants took breaks. Halfway through the battery of cognitive tasks, participants were given a break and asked to fill out the ECQ and ERQ. Finally, they were fully debriefed and compensated.

RESULTS

Manipulation Checks

For three of the four instruction conditions, there were specific ways that participants were asked to behave: suppress expression, regulate inner experience, and maintain emotion. Therefore, it was important to check and see if these manipulations worked.

Participants' Expressions: Checking the Suppress Condition. Since participants in the suppression condition were asked to control their expression of emotions as they watched the film clips, it was important to explore participants' facial expressions. Participants in all conditions were videotaped by a web camera while they were watching the film clip. Once all video data was collected, emotions were coded independently by two research assistants who did not participate in the experiment or in running participants. They were asked to watch each clip (with the volume off) and rate the degree to which people in the clips appeared disgusted, upset, angry, or sad on a seven point scale. This procedure has been used previously by Phillips and colleagues (2008).

The film clip was chosen to elicit disgust, so coders' ratings of disgust were of primary interest. Coders' ratings of disgust were not very high on average, but did vary significantly based on regulation instruction condition (see Table 3.1 for descriptive statistics on ratings). The intraclass correlation for the two coders' disgust ratings was

Table 3.1 *Descriptive statistics for the coders' ratings of participants' disgust while watching the film clips.*

		Minimum	Maximum	Mean (SD)
Regulate	Young	1.00	4.13	1.97 (.857)
	Older	1.13	5.13	2.29 (1.058)
Suppress	Young	1.00	1.75	1.30 (.247)
	Older	1.00	2.50	1.54 (.450)
Maintain	Young	1.13	5.25	2.26 (1.032)
	Older	1.13	5.13	2.691 (1.066)
Neutral	Young	1.00	2.75	1.591 (.429)
	Older	1.13	3.38	1.821 (.613)

.701, which was significant at $p<.05$. The two coders' ratings were averaged to create a displayed disgust score, which is used in subsequently reported analyses.

A 2 (age group) by 4 (condition) ANOVA was conducted using the displayed disgust score as the dependent variable (see Table 3.2 for statistics). Both age groups showed the same pattern of differences in displayed disgust within age group. Post hoc Tukey's HSD comparisons reveal that ratings of the facial expression of disgust were significantly higher in the maintain and regulate groups than in the suppress group for both age groups. In addition, the suppression and neutral groups did not have significantly different levels of displayed disgust, indicating that the suppression groups successfully suppressed their expression of disgust. In addition, no age by condition interaction effect was found, suggesting that both age groups were equally successful at

Table 3.2 *ANOVA statistics for PANAS items, comparing PANAS ratings immediately before and after film clip viewing.*

	Young		Older		Time Main Effect		Time X Age Effect	
	Before	After	Before	After	F	p	F	p
Interested	3.13 (.85)	2.74 (.96)	4.06 (.73)	3.52 (1.23)	14.789	.001	.440	.510
Distressed	1.48 (.85)	1.29 (.53)	1.19 (.60)	1.42 (.72)	.03	.863	5.07	.028
Strong	2.61 (1.09)	2.06 (.93)	3.23 (1.09)	3.03 (1.17)	13.291	.001	3.04	.086
Enthusiasm	2.61 (1.02)	2.19 (1.05)	3.61 (1.13)	3.06 (1.31)	31.991	.001	.569	.454
Proud	2.42 (.89)	1.77 (1.06)	3.32 (1.22)	2.77 (1.41)	28.324	.001	.186	.668
Alert	3.32 (.87)	2.90 (.87)	3.84 (.86)	3.52 (1.09)	12.696	.001	.216	.644
Inspired	1.77 (1.06)	1.52 (.89)	2.97 (1.17)	2.61 (1.26)	6.846	.011	.171	.681
Nervous	1.74 (.89)	1.52 (.63)	1.45 (.77)	1.19 (.60)	6.944	.011	.031	.861
Determined	2.71 (1.16)	2.35 (1.17)	3.48 (1.03)	3.13 (1.26)	12.264	.001	0.00	1
Attentive	3.62 (.85)	3.00 (.93)	3.93 (.83)	3.53 (.97)	8.021	.001	.450	.505
Jittery	1.90 (1.08)	1.55 (.72)	1.23 (.56)	1.19 (.54)	5.347	.024	3.713	.059
Active	3.00 (.97)	2.32 (1.05)	3.26 (1.06)	3.00 (1.21)	14.876	.001	2.989	.089

suppressing their expressions of disgust in the suppress condition, which is consistent with findings by Phillips and colleagues (2008).

PANAS Mood Self-Report Ratings: Checking the Maintain and Regulate Conditions. A 2 (age group) by 4 (condition) by 6 (time) repeated measures ANOVA conducted on the disgust self-ratings from the PANAS revealed no significant age by condition by time interaction, suggesting that the pattern of condition by time disgust ratings were the same for older and young adults.

Our a priori hypotheses for each age group suggested that both age groups would show increases in disgust in the maintain condition and no changes in disgust in the neutral condition. To test these hypotheses, two separate 6 (Time) by 4 (condition) repeated-measures ANOVAs were conducted for each age group using PANAS disgust rating as the dependent variable. For young adults, there was a significant time by condition interaction effect, $F(15, 595) = 25.039$, $p < .001$, partial $\eta^2 = .387$. Tukey's HSD was used to investigate further (alpha=.05). Post hoc pairwise comparisons at Time 3 (just after the film clip) revealed that participants in the neutral condition reported significantly lower levels of disgust than participants in all other regulation conditions. In addition, participants in the suppression condition reported significantly lower disgust than participants in the maintain condition. Young adults in the regulate and maintain conditions did not report significantly different levels of disgust (see Figure 3.1 and 3.2 for graphs).

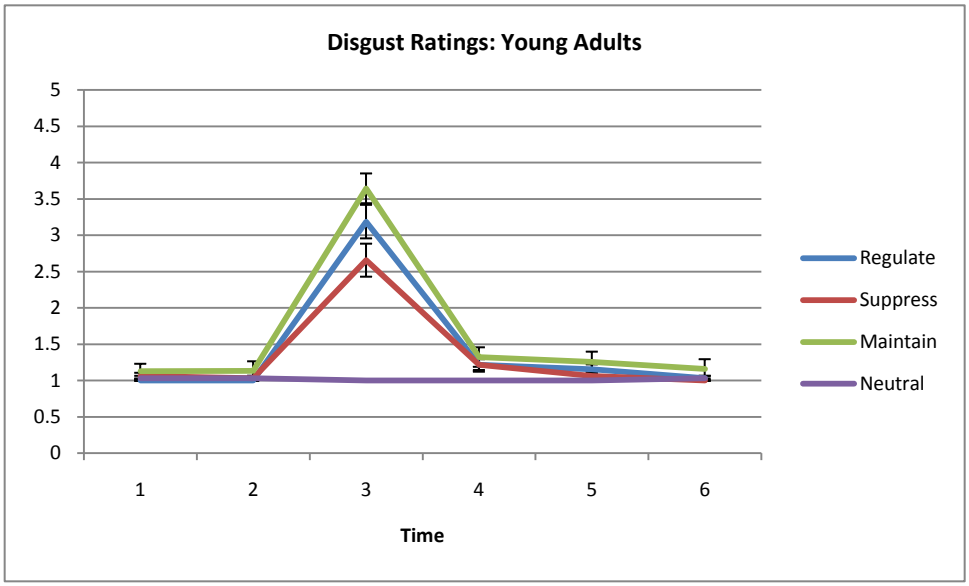

Figure 3.1 *Disgust reported by young adults.*

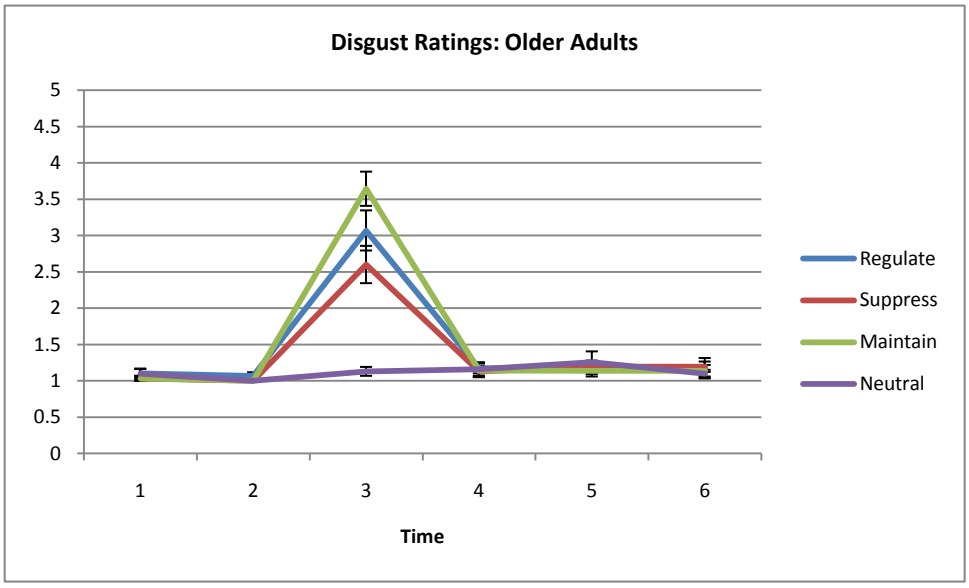

Figure 3.2 *Disgust reported by older adults.*

A significant interaction effect also emerged for the older adults' data, $F(15, 550) = 15.021$, $p<.001$, partial $\eta^2=.291$. Pairwise comparisons revealed the same pattern at Time 3 for older adults: participants in the neutral condition reported significantly lower levels of disgust than all other conditions, and participants in the suppress condition reported lower disgust than participants in the regulate or maintain conditions.

These results demonstrate that participants who watched the disgusting film clip reported greater levels of disgust than those who watched the neutral clip, suggesting that the mood induction worked. In addition, the results confirm that participants in the maintain condition successfully maintained feelings of disgust. However, though participants' in the regulate condition did report lower levels of disgust than those in the maintain condition, this difference was not significant. From their disgust levels, it appears that participants did not regulate successfully.

In addition, those who were told to suppress their expressions of disgust reported lower levels of disgust in response to the film when compared to people who regulated or maintained disgust.

Hypothesis Testing

Hypothesis 1

We expected to conceptually replicate the findings of Scheibe and Blanchard-Fields (2009). We expected to find that young adults perform worse on the Stroop task after regulating emotions relative to their performance in the neutral conditions, but that older adults do not show this same cost associated with regulating emotions.

Hypothesis 2

Suppression of expression should be costly for both older and young adults.

Analyses with Stroop Reaction Time Data. Prior to analysis, the Stroop reaction time data was trimmed to remove outliers within each participant's data. For each participant, the mean and standard deviation of the neutral, congruent, and incongruent trials were calculated separately. Outliers were identified as reaction times that were more than 2.5 standard deviations from the participants' mean reaction time in the given Stroop trial type. Once the reaction time data was trimmed, each participant's Stroop cost was calculated as the mean reaction time to incongruent trials minus the mean reaction time to neutral trials.

Next, outliers in the Stroop cost data were removed. Outliers were defined as people whose Stroop costs were above or below 2.5 standard deviations from the mean of the experimental cell to which they were assigned. Five participants (2 older adults, 3 young adults) were removed using this criteria.

An omnibus 2 (age group) by 2 (time) by 4 (condition) repeated measures ANOVA was conducted using Stroop reaction time costs as the dependent variable. Condition and age group were between subjects factors while time was a within subjects factor. There was a significant main effect of time $F(1, 238)=134.694$, $p<.001$, partial $\eta^2=.361$, such that participants improved performance from block 1 to block 2. There was also a main effect of age $F(1, 238)=104.307$, $p<.001$, partial $\eta^2=.305$, such that older adults had greater Stroop costs than young adults.

Significant interaction effects also emerged. The time by age group interaction was significant $F(1, 238)=36.084$, $p<.001$, partial $\eta^2=.132$, such that older adults improved more on the Stroop task from block 1 to block 2 than young adults did. In addition, the three-way interaction of time, condition, and age group was significant $F(3, 238)=3.22$, $p<.05$, partial $\eta^2=.039$, indicating that participants of different age groups did not react the same way to the different conditions in the experiment.

For each age group, a 2 (time) by 4 (condition) repeated measures ANOVA was conducted using Stroop reaction time costs as the dependent variable. Condition was a between subjects factor while time was a within subjects factor. For young adults, there was a significant main effect of time $F(1, 122)=27.11$, $p<.001$, partial $\eta^2=.182$ such that participants in all conditions had lower Stroop reaction time costs over time. A marginally significant time by condition effect emerged $F(3, 122)=2.603$, $p=.055$, partial $\eta^2=.060$. To investigate this trend, pairwise comparisons (using Tukey's HSD) were conducted, revealing a marginally significant difference between performance in the regulate and suppress conditions ($p=.09$), such that young adults in the suppress condition improved in Stroop performance more quickly than young adults in the regulate condition (See figure 3.3).

For older adults, there was also a significant main effect of time $F(1,116)=105.798$, $p<.001$, such that older adults had lower Stroop reaction time costs at block 2. The time by condition effect was marginally significant $F(3, 116)=2.510$, $p=.062$, partial $\eta^2=.061$. Pairwise comparisons revealed a marginally significant difference in Stroop performance between participants in the maintain and suppression

conditions p=.069, such that older adults in the maintain condition improved in Stroop performance more quickly than older adults in the suppress condition (See figure 3.4).

For each age group, a separate one-way ANOVA was conducted for each block of the Stroop task, using Stroop reaction time costs as the dependent variable and condition as the between subjects factor. At block 1 of the Stroop task, neither age group had significant differences in Stroop performance between conditions. At block 2, however, when depletion costs may have had time to build, significant differences emerged for young adults (but not for older adults). At block 2, there was a significant effect of condition $F(3, 122) = 2.762$, $p<.05$, partial $\eta^2=.064$. Post hoc pairwise comparisons revealed a marginally significant difference in Stroop performance between participants in the regulate and maintain condition p=.053 and between participants in the neutral and maintain conditions p=.089, such that young adults in the regulate and neutral conditions are worse at Stroop than young adults in the maintain condition.

Analyses with Stroop Accuracy Data. A 2 (age group) by 4 (condition) by 2 (time) repeated measure ANOVA was conducted with age group and condition as between subjects factors and time as a within subjects factor and Stroop accuracy as the dependent measure.

The omnibus ANOVA revealed a significant time by age group interaction $F (3, 233) = 21.175$, $p<.001$, partial $\eta^2= .083$ such that older adults improve in accuracy more than young adults do. Separate 4 (condition) by 2 (time) ANOVAs conducted for each age group indicate that whereas older adults became significantly more accurate with

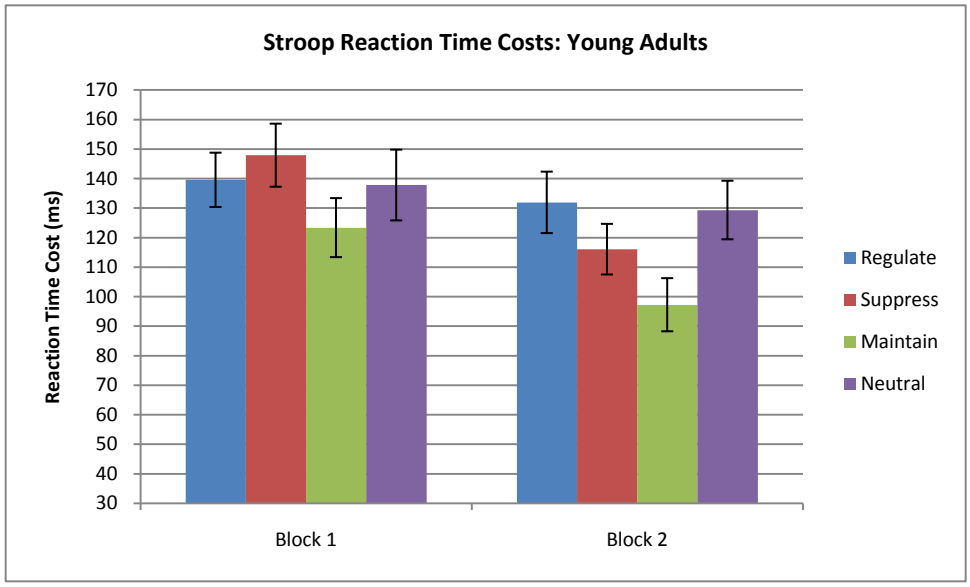

Figure 3.3 *Stroop Reaction Time Costs: Young Adults*

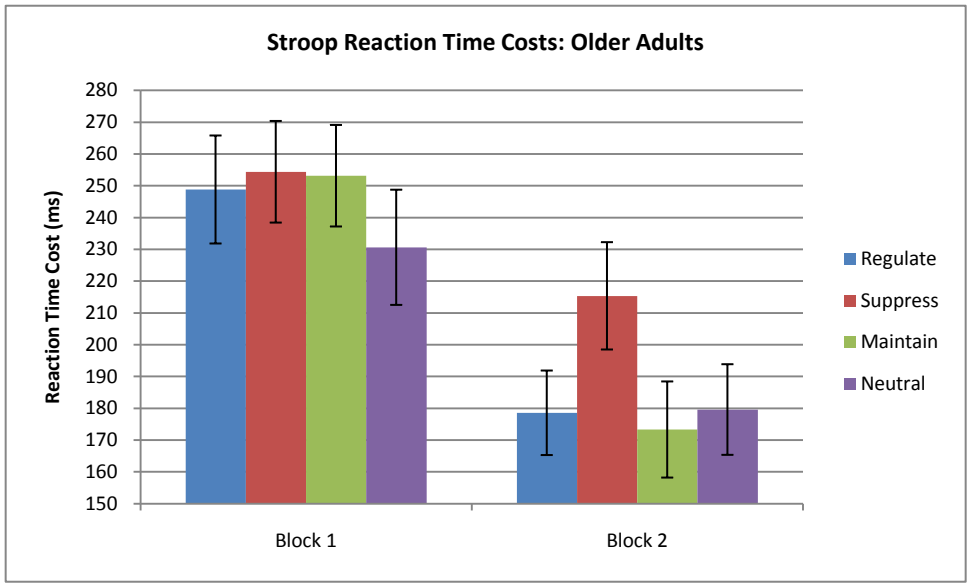

Figure 3.4 *Stroop Reaction Time Costs: Older Adults*

time across conditions ($F(1, 113) = 22.123$, $p<.001$), partial $\eta^2= .164$ young adults did not become more accurate with time (in fact, they became less accurate with time, though this trend is only marginally significant). The omnibus ANOVA also revealed a main effect of age $F(1, 233)=11.866$, $p<.001$, partial $\eta^2= .048$ such that older adults were more accurate than young adults. There were no effects of condition on accuracy, indicating that the depletion effect of emotion regulation was not discernable by looking at accuracy levels on the Stroop task. Accuracy was high (see figure 3.5 and 3.6).

Hypothesis 3

Finally, we conducted exploratory analyses to investigate whether emotion regulation strategy use or cognitive functioning were related to Stroop performance. We conducted the same sets of 2 (time) by 2 (age group) by 4 (condition) repeated measures ANOVAs using reaction time and accuracy as dependent variables, this time using cognitive functioning or emotion regulation strategy use as covariates in the analyses. Including covariates had no significant effect on the results.

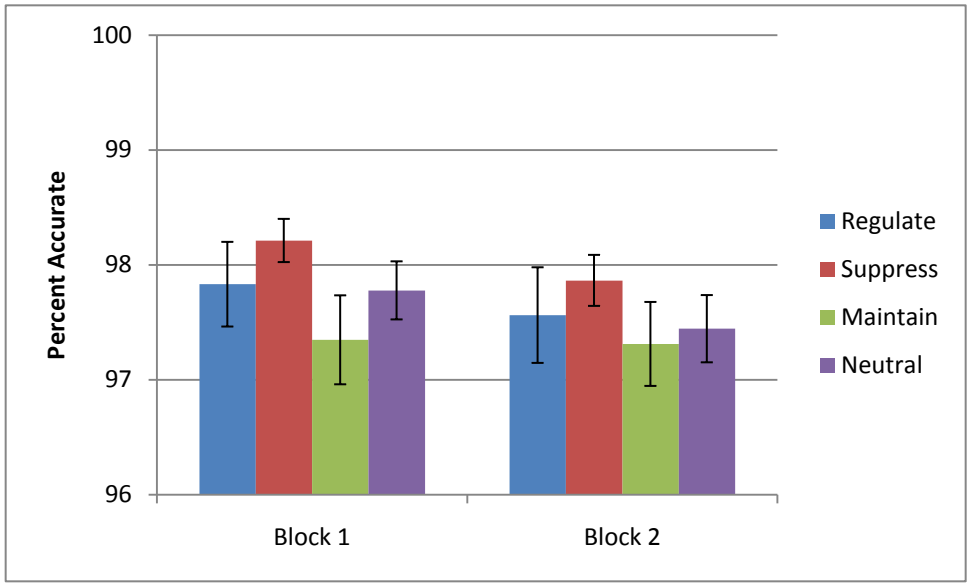

Figure 3.5 *Stroop accuracy for young adults.*

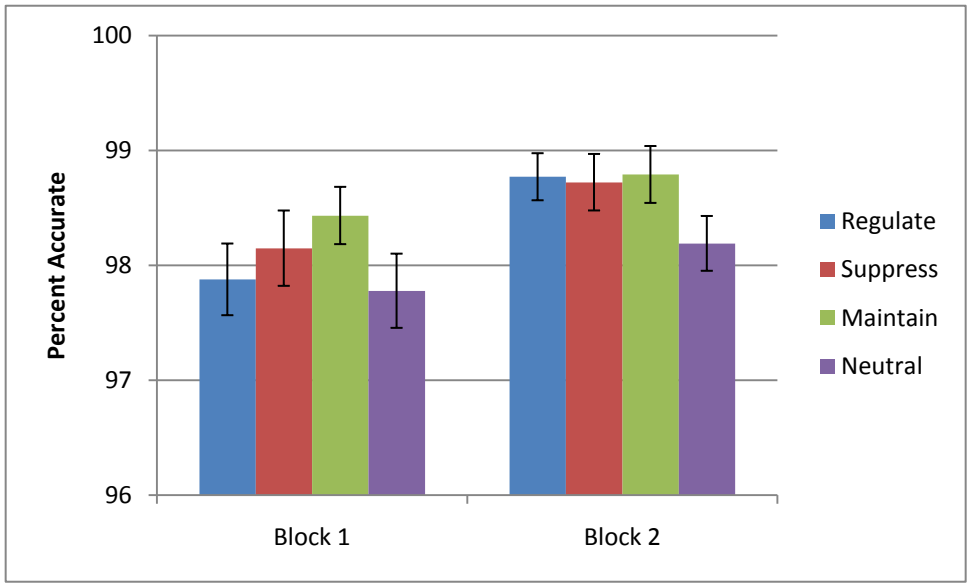

Figure 3.6 *Stroop accuracy for older adults.*

DISCUSSION

The study investigated age differences in the extent to which emotion regulation depletes cognitive resources and thus has a subsequent effect on cognitive performance. The act of engaging in emotion regulation strategies was expected to deplete cognitive resources in young and older adults, resulting in lowered performance on a subsequent Stroop task. The study specifically investigated the differing cognitive costs of two forms of emotion regulation: suppressing external expression of emotions and regulating inner experience of emotions. To study these phenomena, participants were asked to follow emotion-related instructions (suppression, regulation, maintenance, or neutral instructions) while watching a film clip, and then they completed a Stroop task. Because the Stroop task requires self-control resources (as described by Baumeister), performance on the Stroop task was expected to be poorer if the previous emotion-related instruction/film clip phase of the experiment also required self-control resources.

The study found support for the hypothesis that different emotion regulation strategies may be differentially efficient for people of different age groups. For young adults, one important difference between conditions was a contrast between the magnitude of practice effects for the suppress and regulate conditions. In other words, young adult participants in the regulate condition improved significantly less on the Stroop task over time compared to young adults in the suppress condition. This supports the idea that for young adults regulating the inner experience of emotions leads to a greater depletion effect than suppressing emotions, which would indicate that young

adults may have had to use greater self-control resources when regulating emotions than when suppressing them. Further, young adults in the regulate condition performed significantly poorer than young adults in the maintain condition during the second block of Stroop trials, when depletion effects may have had time to accumulate, which also suggests that regulating emotions may be particularly costly for young adults. Scheibe and Blanchard-Fields (2009) also found increased costs associated with regulating emotions for young adults, though in their study, there were increased costs of regulating compared to the neutral condition.

For older adults, the only significant difference in conditions in our study occurred in the comparison of the practice effects between the maintain and suppress conditions. In the maintain condition, older adults showed steeper practice effects than in the suppress condition, indicating that suppressing emotions may require more resources than maintaining them.

In summary, young adults show greater depletion costs associated with regulating emotions than suppressing or maintaining them. Older adults show greater costs for suppressing emotions than maintaining emotions, suggesting that suppressing emotions may require significant cognitive effort to perform successfully for older adults (in contrast to regulating emotions, which is not different from maintaining them). It should be noted that the conclusions for young and older adults are based on qualitatively different comparisons. For young adults, the conclusions are based on comparing the suppress with the regulate condition and the regulate with the maintain condition, whereas the conclusions for older adults are based on comparing the suppress with the maintain condition.

The pattern of results suggests that regulating and suppressing emotions are two different processes that require different amounts of effort to perform. In addition, there seem to be age differences in the costs of these two types of emotion regulation. Whereas young adults seem to expend more effort in order to regulate emotions, older adults seem to expend more effort suppressing emotions.

Though some of our findings support our hypotheses and are consistent with previous research, some findings were unexpected. Previous work with young and older adults suggested that there would be no cost associated with regulating emotions for older adults, but that there would be a cost for young adults (Scheibe & Blanchard-Fields, 2009). As expected, we found no evidence for regulation costs for older adults. Also, as described above, some evidence suggests that regulating emotions may be costly for young adults in this paradigm. Unexpectedly, we did not see costs for regulating for young adults relative to the neutral control condition. However, upon further inspection of the neutral condition, it appears that participants in that condition may have found the neutral film clip to be boring or frustrating, which may mean that they were feeling unintended negative emotions instead of neutral emotions. For example, in the neutral condition, people of both age groups were less likely to feel interest, strength, enthusiasm, pride, alertness, inspiration, determination, attentiveness, and activeness after the film clip. Consequently, our neutral control group may not be valid.

Another unexpected finding is based on previous work by Richards and Gross (2000) which suggests that, for young adults at least, suppressing emotions should be more costly than regulating them. However, we think a difference in paradigms can explain the difference in findings between Richards and Gross's work and ours. Richards

and Gross's study used a dual task paradigm during which people regulated or suppressed emotions while watching a film clip. Participants were then asked questions about the content of the film clip. People who suppressed expression during the clip had worse memory for the clip than people who regulated, which could be interpreted as suppression requiring more effort than regulating. However, the results could also be a function of the way people pay attention to the film clip during the instruction conditions. People asked to suppress their expression may pay more attention to their faces and bodies, leaving less resources to process the film clip, whereas people asked to regulate their emotions may not have to draw attention away from the film clip in order to successfully regulate. Consequently, the two groups would have different levels of memory for the content of the clip despite having (perhaps) spent the same amount of effort following instructions. In the depletion paradigm, however, the amount of cognitive resources used to enact the emotion-relation instructions is measured according to how much cognitive resources are depleted in a second task, which should not be affected by what aspects of the previous task participants were attending to, but instead by how much effort they were putting into the tasks they were performing.

Baumeister's work also suggests that there should be a cost of suppression (though it does not address a relationship between suppression and regulation). In many studies, including a study similar to ours that used the Stroop task after a mood induction/suppression phase, Baumeister and colleagues (in press) repeatedly find depletion costs associated with suppressing expression in young adults. Whereas we find a suppression cost in older adults (when we compare it to maintaining emotion), we did not find a suppression cost for young adults. One important difference between

Baumeister's studies and ours is the emotion elicited during the study. Whereas our study uses regulation and suppression of disgust, Baumeister's work has mostly utilized films and other emotional stimuli that elicit sadness, anger, or feelings of injustice. Recent work in our lab suggests that taking a discrete emotions perspective when looking at cognitive costs of emotion regulation is crucial. Different emotions appear to have different cognitive costs, and the costliness of regulating or suppressing particular emotions may vary by age group. In the current study, young adults may not display the typical suppression effect found by Baumeister because the emotion disgust may not be as difficult for them to suppress as the sadness and anger emotions typically used by Baumeister. Our particular disgust induction may also have been easier to suppress for young adults because the film clip may be more youth oriented. The clip was taken from a reality show that may be more culturally relevant to the young cohort.

Older adults, on the other hand, may find disgust to be particularly difficult to suppress, or further research may reveal that older adults generally have more trouble suppressing negative emotions. Follow-up research should be conducted to determine whether the depleting effects of suppressing disgust are specific to the emotion disgust for older adults. In addition, reactions to more age-relevant disgust-eliciting film clips may be easier for older adults to suppress, so follow-up research with age-relevant disgust clips would be informative.

Despite some unexpected findings, the study extends our knowledge in important ways. Previous work suggested that older adults need to use less effort to regulate emotions compared to young adults (Scheibe & Blanchard-Fields, 2009). This study, however, suggests that highly efficient emotion regulation in older adults may only

encompass certain kinds of emotion regulation, like the regulation of inner experience. For other kinds of emotion regulation, like suppression of expression, older adults may have to use greater cognitive resources. This could explain why older adults frequently do not endorse strategies like suppression of expression (John & Gross, 2004) and do not seem to improve at suppression of expression despite improvements in regulation of experience (Phillips et al, 2008).

This study also expanded previous research by looking at the cognitive costs of regulating an emotion while the emotional event was ongoing, rather than regulating emotions after the emotional event. In previous work, older and young adults both successfully down-regulated negative emotions following the disgusting film clip used in our study (Scheibe & Blanchard-Fields, 2009). In the current study, however, neither age group had significantly lower levels of disgust in the regulate condition than in the maintain condition following the film clip, despite being asked to down-regulate while watching the clip. These findings could highlight some important differences between regulating emotion during ongoing emotional events and regulating emotions following events. Whereas people may be able to easily choose effective strategies and enact them once an emotional stimuli is removed (with older adults doing this using fewer cognitive resources than young adults), regulating during an ongoing emotional event may be more demanding. In the Scheibe and Blanchard-Fields study, many participants reported using the cognitive task to distract them from the emotions the film had elicited. In the depletion paradigm, this may be more difficult because there is no obvious task to focus on other than the disgusting film clip. Distracting oneself from the emotional stimuli

may be a particularly effective strategy, which is not as easily deployed when the stimuli are still present.

Finally, the study expands upon past research by confirming that there are age differences in the cognitive costs of emotion regulation using a different paradigm and different cognitive tasks. Though past research suggested that regulating emotions after an emotional event was costly for young adults but not for older adults (Scheibe & Blanchard-Fields, 2009), the current study suggests that the pattern may be slightly different for regulating ongoing emotions. However, what is consistent between the two studies: there are age differences in costs of different emotion-related strategies. For older adults, there appear to be cognitive costs associated with suppressing expression during ongoing emotional events, but no costs to regulating emotions during ongoing events or following emotional stimuli. For young adults, there appear to be cognitive costs to regulating emotions following emotional stimuli, and there may be cognitive costs associated with regulating emotions during ongoing emotional events, though suppressing expression of emotion during ongoing emotional events does not appear to have cognitive costs.

Though the study suggests that there are age differences in the cost of different emotion-related strategies, there are some limitations in the current study. First, our neutral control group did not behave differently from any of the experimental groups on the cognitive task. As mentioned before, however, this may be due to boredom that may have been unintentionally elicited by the neutral film clip. In future research, a different neutral film clip—one that is engaging but not emotional—should be used.

Further, in the current study, neither older nor young adults regulated particularly successfully. If participants had regulated effectively while watching the film clip, we would expect PANAS ratings of disgust to increase less from T2 (right before the clip) to T3 (right after the clip) for the regulate condition than for the maintain condition. Actually, disgust increased at the same rate for both conditions. This could be a function of the difficulty of regulating when the emotional stimuli is ongoing. It could also be a function of our particular regulation instructions, which may have encouraged participants to use a strategy that was not optimal. Our instructions specifically ask people to change negative emotions into positive ones. Future instructions should include other kinds of strategies including distracting oneself and trying to reappraise the stimuli.

Finally, disgust was difficult to elicit in many participants. Fifty-five participants were removed from the study—most of them were removed because they did not feel disgusted. In addition, the film clip often elicited both disgust and amusement, which could complicate the results. Future research should investigate the costs of regulating other, more easily elicited emotions or should use a different film clip to elicit different, more enduring emotions such a sadness or anger. The film clip used for this study was taken from a reality show that airs specifically to amuse people. Future disgusting clips might be taken from other sources.

In conclusion, older and young adults appear to require different amounts of resources to regulate ongoing emotions using different strategies. Young adults appear to need fewer resources to suppress expression of emotions than to regulate experience of emotions, which might explain why previous studies have suggested that they are more

likely to endorse suppression as a strategy for dealing with emotions. Older adults, on the other hand, may find suppression of expression costly, which may explain why they do not report improvements in ability to suppress emotions and why they do not show improvements in suppressing expression in experiments (Gross et al, 1997; Phillips et al, 2008). Rather than having reduced cognitive costs associated with all forms of emotion regulation, older adults appear to regulate emotions more efficiently than young adults, but they may not suppress emotions more efficiently.

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